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Development of the Automated Performance Assessment and Remedial Training System (APARTS) is described. APARTS is an automated training aid designed to assist the Landing Signal Officer (LSO) in training pilots during the acquisition of carrier landing skills. APARTS is based on general principles of learning and provides graphic displays of pilot landing technique problems for LSO evaluation and pilot feedback. APARTS also integrates Field Carrier Landing Practice (FCLP), conducted in the aircraft, with Night Carrier Landing Trainer (NCLT) instruction. Once landing problems are identified and feedback (over)

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20. Abstract (cont.)

is provided to the pilot, remedial instruction is given in the NCLT. An improved APARTS conceptual model along with two computer programs designed to process, store and graphically display pilot performance data are described. Future APARTS developments are outlined for improved carrier landing training effectiveness.

FOREWORD

The present research illustrates a long-standing goal of the Human Factors Laboratory to optimize simulator utilization based on performance measurement. With the APARTS (Automated Performance and Remedial Training System) training technology described in this report, it is now possible to guide the use of the Night Carrier Landing Trainer (NCLT) on the basis of night landing problem diagnostics measured during Field Carrier Landing Practice (FCLP). In contrast to the "block" form of simulator use wherein all students receive identical or highly similar sequencing of instruction and training content, APARTS permits integration of training between the aircraft and simulator media. To provide rapid, organized, individualized feedback, including trend data, the APARTS is automated using the latest hardware and software configurations to enhance operational user acceptance. Due to the high user acceptance of the first version of APARTS reported here, a draft operational requirement has been written for consideration by the Chief of Naval Operations.

Gerald R. Stoffer

GERALD R. STOFFER
Scientific Officer

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SECTION I
BACKGROUND

This is the third in a series of reports which describe the development and application of automated and integrated training approaches to improve night carrier landing through more effective utilization of training devices. The first report on A7 training effectiveness reviewed the results of a training method which emphasized individualized instruction in a Night Carrier Landing Trainer (NCLT) in order to correct landing technique problems encountered by novice pilots during Field Carrier Landing Practice (FCLP).[1] Costly recycle training was reduced by this method and resulted in improved pilot landing performance during initial Carrier Qualification (CQ) trials.

The conceptualization and partial automation of the performance measurement system used in the A7 study was outlined in a second report.[2] This report described a conceptual plan to assist the Landing Signal Officer (LSO) in training carrier landing skills via two computer programs which processed and summarized FCLP performance data on printouts provided for training feedback. The system that evolved was called the Automated Performance Assessment and Remedial Training System, or simply APARTS. New diagnostic feedback techniques and remedial training were emphasized with APARTS.

APARTS gained recognition in the fleet, especially in the Fleet Readiness Squadrons (FRS), where novice Replacement Pilots (RP's) receive their training in fleet aircraft. The final phase of FRS training consists of carrier qualification training and culminates in landing day and night aboard an aircraft carrier. The training sequence starts in the training device (NCLT),

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[1] Brictson, C.A. A7 training effectiveness through performance analysis (Report No. NAVTRAEQUIPCEN 75-C-0105-1). Orlando, Florida: Naval Training Equipment Center, April 1978.

[2] Brictson, C.A. & Breidenbach, S.T. Conceptual development of a preliminary LSO carrier landing training aid. Naval Training Equipment Center contract N61339-77-C-0166. La Jolla, California: Dunlap and Associates, Inc., April 1980.

proceeds to the aircraft (FCLP) and ends at the boat (CQ). Each is a separate block of training designed to promote step-by-step landing skill acquisition from trainer to aircraft to ship. Often, however, these steps are performed in isolation with little integration between aircraft and trainer performance. APARTS was found to be useful to LSO's in processing, organizing and analyzing the large quantity of FCLP performance data previously handled manually. This capability was used by LSO's to isolate individual pilot landing technique problems in the aircraft and subsequently to provide remedial instruction in the NCLT to correct these problems in the trainer.

During the interim stage of development, the semi-automatic APARTS became outdated and was no longer efficient because of cumbersome equipment size, lack of graphics capability, storage limitations and software constraints. The renovation and full automation of APARTS is described in this report. APARTS capabilities are now supported by a highly portable desktop computer with state-of-the-art graphics technology, greatly expanded memory and enhanced user-oriented software.

SECTION II

APARTS CONCEPTUAL DEVELOPMENT

WHAT IS APARTS?

APARTS is an automated training aid designed to assist the LSO in training pilots during the acquisition of carrier landing skills. APARTS provides the LSO with detailed diagnostic training information on each pilot's progress during FCLP. This information is used to integrate actual aircraft training (FCLP) with various trainer devices (e.g., NCLT) to promote more effective pilot learning and to establish a pilot performance data base. APARTS accomplishes these objectives by incorporating the following fundamental psychological principles of learning.

- Meaningful organization of information,
- Problem analysis,
- Immediate knowledge of results (KOR),
- Individualized instruction, and
- Remedial instruction.

These principles serve as an integral part of the APARTS conceptual framework which is presented in Figure 1.

As depicted in Figure 1, the learning principles are mediated through computer software programs which result in program outputs. In practice, pilot FCLP performance data are analyzed and organized in a meaningful manner on outputs which graphically portray each pilot's landing technique problems. These outputs serve as knowledge of results for the pilot and give an indication of training progress and problems to the LSO. The LSO evaluates the results and then recommends remedial training to correct the problems. The remedial, or corrective training, is provided on an individualized pilot basis, and is administered in a training device such as the NCLT. The entire APARTS process thus fosters the concept of integrated training by continuous feedback of aircraft landing diagnostics throughout the NCLT sessions. Actual aircraft training is combined with the training device and not conducted in isolation.

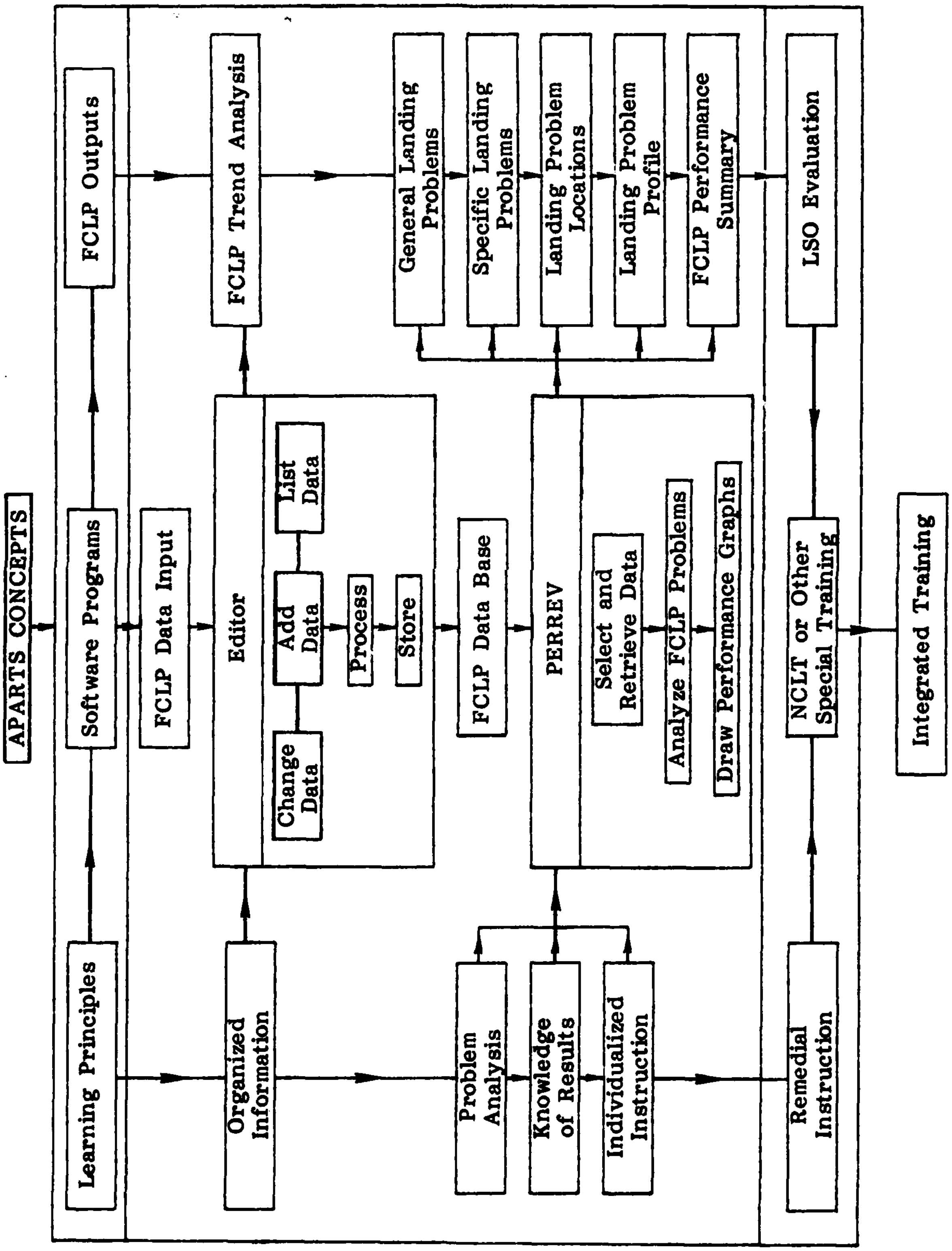

Figure 1. APARTS conceptual framework

WHAT APARTS PROVIDES TO LSO's

APARTS provides automated performance assessment and remedial training information to assist the LSO in CQ training. In addition to these general capabilities, APARTS promises to provide many additional specific features that the LSO can use in his everyday pilot training. Some examples are:

- Integrated (FCLP/NCLT) training through the use of FCLP performance in NCLT training.
- Training data continuity over time, with the fleet, across instructors, within students and across east and west coast training facilities.
- Training data quality control by facilitating standard LSO comments and providing for error detection and correction.
- Automated performance data processing which is fast, efficient, and reliable.
- Meaningful organization and visual display of information.
- Individualized diagnosis of pilot landing problems.
- Timely feedback of performance results.
- Hard copy printout of performance data.
- Narrative problem summary for NCLT correction.
- Reduced LSO workload through automation of record keeping.
- Pilot performance data base for syllabus validation, development of normative landing/learning data and group performance trends.

SECTION III

APARTS CONFIGURATION

HARDWARE

All software programs written for APARTS are designed to operate on the Hewlett-Packard Series 9800 desktop computer. The computer, commonly referred to as System 45, integrates a number of state-of-the-art components within a desktop unit that is small, portable and self-contained. Figure 2 illustrates the integrated and compact design of the System 45. Built-in components of the System 45 include: typewriter-like keyboard, 187 K byte memory, Cathode Ray Tube (CRT), two tape drives and thermal printer. Optionally, the System 45 supports via Read Only Memory (ROM) modules a number of other peripheral devices such as high-speed printers, floppy disk and hard disk systems which would greatly expand and enhance the current capabilities if the need arises.

System 45 utilizes an enhanced version of BASIC computer language. This language version is powerful in that it provides for matrix and string manipulations, error trapping, flexible tracking, mass storage operations, multi-character variables and subprogram capability. Yet, the BASIC language system is easy to program since it is highly interactive and conversational with the user. Being a turn-key system in which the BASIC operating system is automatically loaded from ROM's at power on, even a computer novice has little difficulty operating the System 45.

SOFTWARE

APARTS software consists of two independent, but interactive, programs. Complete listings for these programs along with "human readable" documentation are presented under separate cover.[3] Each program is comprised of

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[3]Breidenbach, S.T. & Krasovec, F. Automated Performance Assessment and Remedial Training System (APARTS) program documentation. La Jolla, California: Dunlap and Associates, Inc., February 1981.

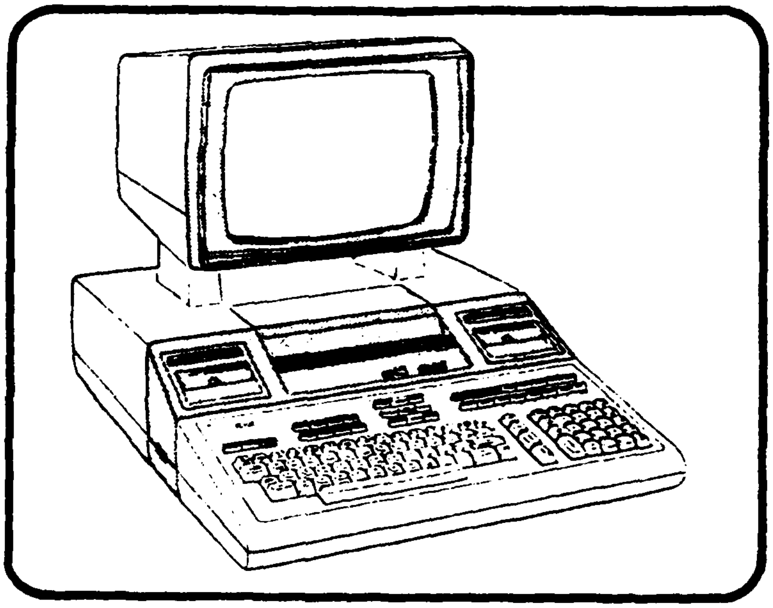


Figure 2. Illustration of Hewlett-Packard System 45 computer

numerous subprograms. This modular feature provides tremendous program flexibility. For example, subprograms were developed independently and later integrated into APARTS software with minor modifications. Updates or new subprograms providing future extended capabilities may be added easily to the system. The modular design also reduces the total amount of computer memory required to run the programs.

APARTS software incorporates a number of "user friendly" features. For example, the user is always prompted prior to any required action. All prompts are easy to understand and many examples are included. Clarity is also maintained through standardization of prompt formats.

APARTS is also a "smart" system which performs many functions for the user. Some examples of this feature include the following:

1) it is difficult for the user to disrupt the system operation (i.e., pressing keys at the wrong time does not "hurt" the system),
2) demographic data entered into the system are automatically error checked and feedback is provided when errors are detected,
3) performance data can be entered in a variety of formats and the system will automatically convert these data to a standard format, and
4) pilot names and dates can be accessed by simply entering numbers on the keyboard.

SECTION IV

APARTS SOFTWARE PROGRAM DESCRIPTION

APARTS software consists of two computer programs which are named Editor and Performance Review (or briefly, PERREV). The functions performed and outputs provided by these two programs are described below.

EDITOR PROGRAM

Editor is a computer program which provides the capabilities to add, change, list, process and store FCLP performance data. The data input to Editor consists of LSO grades and comments of a pilot's performance for up to 12 landing approaches during each FCLP period. These performance data are usually recorded by an LSO on an FCLP Grade Sheet, an example of which is presented in Figure 3. To transfer data into Editor the user transcribes and manually enters the performance data from the FCLP Grade Sheet via the computer keyboard.

Once entered into the computer, Editor processes the raw FCLP performance data and prints out an FCLP Trend Analysis form. The FCLP Trend Analysis output for the FCLP Grade Sheet data presented in Figure 3 is shown in Figure 4. The format of the FCLP Trend Analysis is consistent with the trend form found in the LSO manual and used by Navy fleet squadrons. As presented in Figure 4, each row of the FCLP Trend Analysis shows the abbreviated LSO comments for a single landing approach. Each column represents a category of landing technique errors. Average LSO grades are automatically calculated and printed at the bottom of the FCLP Trend Analysis. To summarize, Editor organizes raw performance data into content categories which are more understandable and meaningful to LSO's and student pilots alike. This process exemplifies the learning principle of meaningful organization of material.

Beyond the input and processing of FCLP performance data another important function of Editor involves the storage of FCLP data. By writing FCLP data on tape, a permanent, historical data base is established. Not

DATE 20FEB80		LSO Hill RT
A/C 234		PILOT Recycle IM
1	B	HAW BAR
2	B	HCDAW DECIC BAR
3	WO	SRDIM HFNDIC-AR
4	B	HAW
5	(OK)	SRDIM (H)CDIC-AR
6	B	OC DECSIM (H)BIC-AR
7	—	OC NEPX HIM NDIC (H) BAR
8	OK	(DECIM) (BAR) (NDTL)
9	B	DECIM OSIC BAR
10	(OK)	HX-IM (TMPIC) (LR)
11		
12		

PTS

PASS: GRADE

DAY: NIGHT:

Figure 3. APARTS input: FCLP Grade Sheet

FCLP TREND ANALYSIS

PILOT: FEC[illegible]LE IM DATE: 20FEB80-NIGHT

LSO: HILL RT SQUADRON: VA122 ACRFT TYPE/SIDE: A7E/234

# GRD	GLIDESLOPE & SPEED ERRORS					CONTROL ERRORS		LINEUP	
	AW	X	IM	IC	AR	POWER	ATTITUDE	& WINGS	OTHER
1 B>	H				B				OTOP
2 B>	H CD			DEC	B				
3 WO			SRD	H F	H F		NDIC NDAR		
4 B>	H								
5 (OK)			SRD	(H) CD	(H) CD				
6 B>			OCDEC OCS	(H) B	(H) B				OTOP
7 --			H		(H) B	OCNEPX	NDIC		
8 OK			(DEC)		(B)		(ND)TL		
9 B>			DEC	OCS	B				OTOP
10 (OK)		H	H			(TMP)IC			(LR)

Average Grade = 2.6
Standard Deviation = .76

Figure 4. APARTS output: FCLP Trend Analysis

only does the Editor program provide initial data storage capability, but it also enables the user both to view and make changes to the stored data. This update function of Editor ensures data integrity and quality control by providing a method to verify the accuracy of all entries.

PERFORMANCE REVIEW--PERREV PROGRAM

The functions of PERREV are to provide the LSO with ready access to and review of large quantities of FCLP performance data previously processed and stored by Editor. PERREV selects and retrieves FCLP data, analyzes FCLP problems and draws performance graphs. PERREV incorporates state-of-the-art computer graphics technology which enables the LSO to review pilot performance summary data. The data are graphically organized to highlight the landing technique strengths and weaknesses for each pilot. If the LSO chooses, he may obtain a hard copy of each graph for use in debriefing the pilot or he may simply review pilot performance on the CRT. The former method provides a permanent, detailed, diagnostic analysis of pilot performance which can be used for remedial training purposes. The rest of this section will describe the graphic performance outputs produced by PERREV using FCLP data.

PILOT PERFORMANCE GRAPH OUTPUTS

Program PERREV currently has the capability for selecting data from the FCLP data base and drawing as many as five pilot performance graphs for the LSO. The titles of the graphs are:

- General Landing Problem Type,
- Specific Landing Problem Type,
- Problem Location From Touchdown,
- Landing Problem Profile, and
- FCLP Performance Summary.

These graphs are designed to summarize and display the type, frequency, and location of landing technique problems for each pilot during an FCLP period consisting of up to 12 landing approaches. The LSO uses the graphs

for diagnostic training feedback and to provide each pilot with knowledge of results necessary for effective learning. The graphs may be viewed automatically, in sequence, with a hardcopy printout, or they may be selected individually for viewing on the CRT. This feature provides the LSO with a decision option depending on the diagnostic depth of his analysis for any particular pilot. For low performers, more detailed hardcopy data may be desired, while for high performers only a CRT view of performance may be adequate. The LSO controls the depth of diagnostic detail for each pilot.

GENERAL LANDING PROBLEM. The first graph, called General Landing Problem Type, outlines in terms of the relative frequency of LSO comments, the general type of landing technique problems that occurred for a pilot during a specific FCLP period. Twelve FCLP landing approaches can be summarized on this graph. General landing problems are broken down into eight categories for analysis. As presented in Figure 5, the primary landing problems for the example pilot were related to glideslope and descent rate. Fifty-eight percent of all LSO comments were made on either glideslope (28 percent) or descent rate (30 percent). On a positive note, in terms of pilot strengths, the graph also indicates that the pilot had no difficulty with line-up and wings, very little difficulty with power (4 percent) and only slight difficulty with attitude (8 percent) and speed (13 percent). The graph provides a general overview of pilot performance for a complete FCLP period, day or night.

SPECIFIC LANDING PROBLEM. To provide a further analysis of landing technique problems, a second graph, called Specific Landing Problems, is also drawn on the CRT. This graph, presented in Figure 6, shows specific information on the four most frequent landing technique problems. While the graphic presentation in the first graph, General Landing Problem, revealed only that glideslope control was one major problem for the pilot, this graph provides detailed information on whether the pilot was flying the aircraft too high or too low relative to the optimum glideslope. A review of Figure 6 shows that all LSO glideslope comments (28 percent) refer to the pilot being high, or above the optimum glideslope. For descent rate, 10 percent of the comments were for too much (TM) rate of descent and 19 percent for not

FIELD CARRIER LANDING PRACTICE (FCLP)

Pilot: RECYCLE IM | Squadron: VA122 (A7E)

Date: 20FEB80 → NIGHT | # Passes = 10

Period: 5

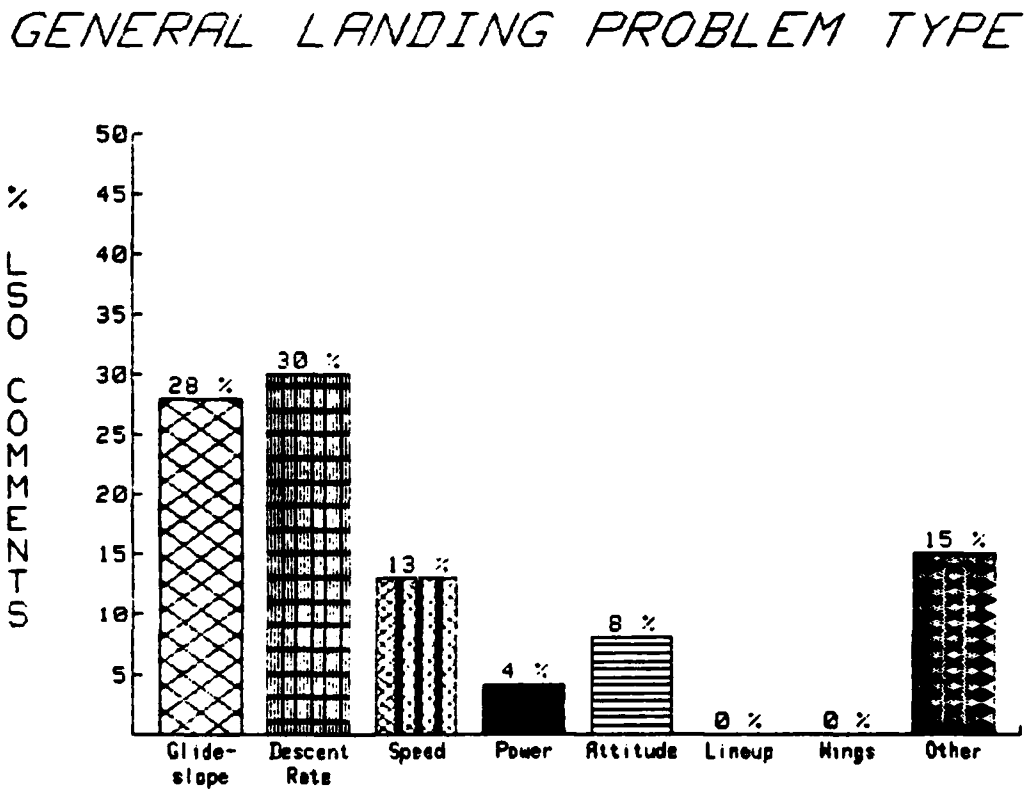


Figure 5. APARTS pilot performance graph output: General Landing Problem Type

FIELD CARRIER LANDING PRACTICE (FCLP)

Pilot: RECYCLE IM
Date: 20FEB80 → NIGHT
Period: 5

Squadron: VA122 (A7E)
Passes = 10

SPECIFIC LANDING PROBLEM TYPE

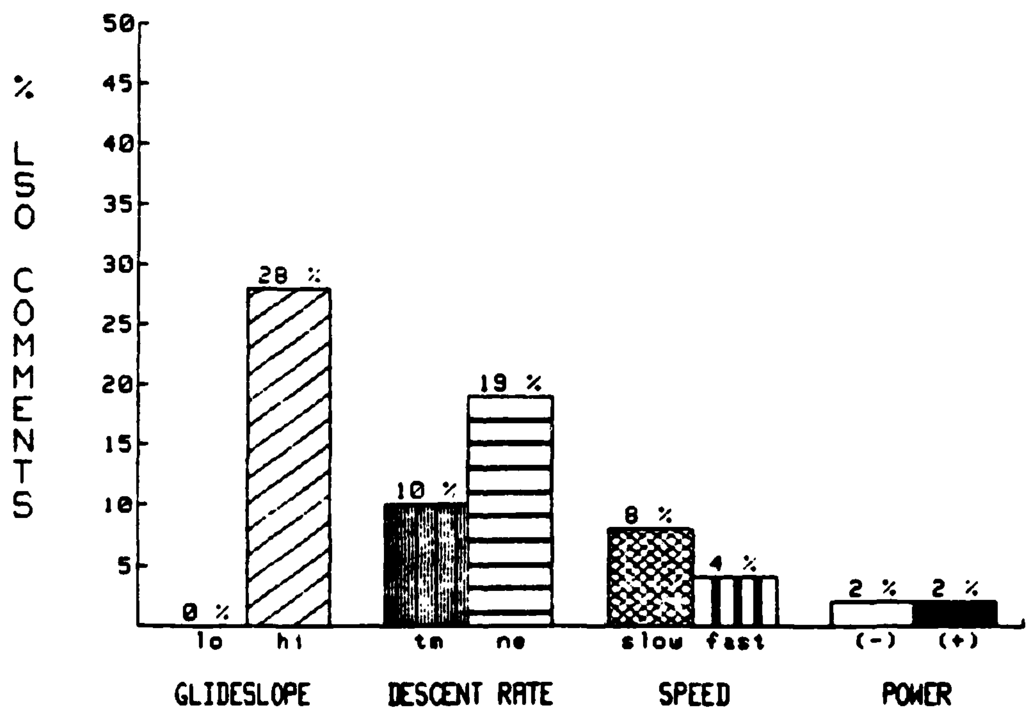


Figure 6. APARTS pilot performance graph output: Specific Landing Problem Type

enough (NE). With this graph the LSO has access to more detailed diagnostic performance data on the quality of FCLP approaches for each pilot.

PROBLEM LOCATION FROM TOUCHDOWN. Thus far, the two graphs presented have focused exclusively on the types of problems that the pilot experienced. The graphs do not indicate where, in relation to distance from touchdown, the landing technique problems occurred. This information, however, is provided to the LSO in a separate graph which identifies the landing problem location from touchdown (see Figure 7). The graph depicts in a frequency histogram the relative percentage of all LSO comments made for each of six locations from touchdown. Each location segment shows a gradually increasing percentage of comments beginning with the start (X) 12 percent, in the middle (IM) 24 percent, in close (IC) 29 percent, and finally, at the ramp (AR) 33 percent. It should be noted in this example that the majority of pilot landing problems occurred at the ramp, which is the final segment prior to touchdown. On the other hand, no LSO comments were made at the turn or prior to the start and only 2 percent of all comments dealt with wire information or touchdown performance.

All this information is useful to the LSO in isolating the location of the landing technique problems a pilot has during his FCLP approaches. The example provided in Figure 7 summarizes LSO comments on the fifth night FCLP period for ten night passes. The graph illustrates the gradually increasing percentage of LSO comments as the pilot approaches touchdown (wires), and is fairly typical for a beginning pilot at this stage of night FCLP training. By contrast, the first night FCLP period typically shows a reversed trend of problem locations. That is, most of the LSO comments occur at the start of the approach when the pilot is first learning how to set up his final descent. This graph indicates the pilot has mastered the start and is learning the final stages of the approach (in close and at the ramp).

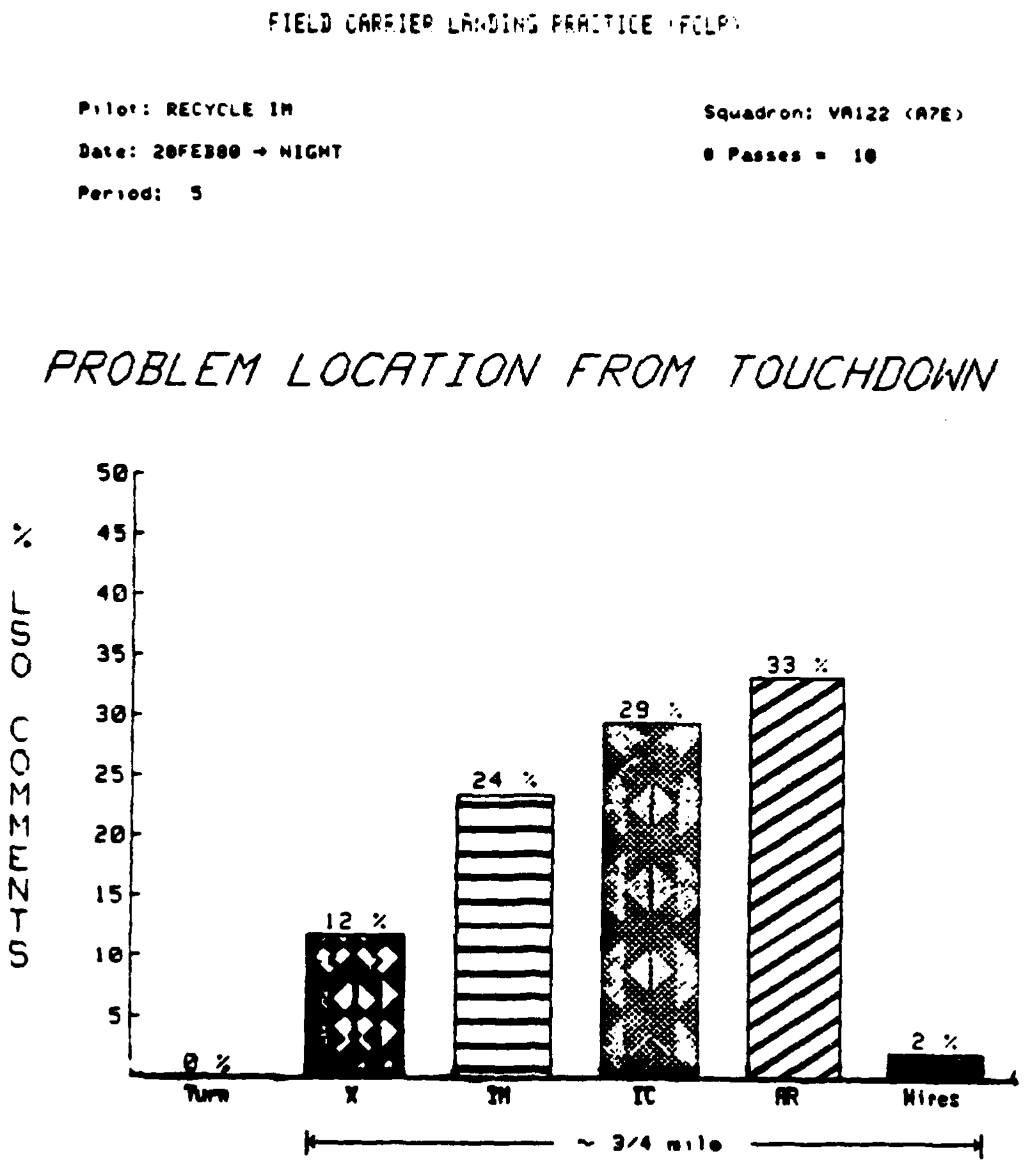


Figure 7. APARTS pilot performance graph output: Problem Location From Touchdown

LANDING PROBLEM PROFILE. In addition to the isolated views of landing problem types (Figures 5 and 6) and locations (Figure 7) the LSO may view the interaction of these landing problems. The Landing Problem Profile, as presented in Figure 8, is a topographical chart designed to reflect both type and location of landing problems in one display. Problem locations are displayed along the vertical axis and problem types along the horizontal axis.

All of the graphs previously described are based on equally weighted LSO comments. The Landing Problem Profile graph, however, uses differentially weighted comments in order to include the magnitude as well as the frequency of landing technique comments. The following weighting system is utilized:

LSO Comment	Weight	Meaning
$\underline{\text{H}}$	3	High (underlined for emphasis)
H	2	High (normal comment)
(H)	1	Slightly high (parentheses signify "slightly")

Frequencies of these weighted LSO comments are then categorized into four different frequency ranges. Each frequency range is represented graphically with a unique fill or shade code. The highest frequencies, for example, are completely filled (black cells) and signify the most frequent (highest percentage) problem areas. The three highest frequency problem areas are printed below the graph to provide a specific list of the three main landing technique problems. This information is used by the LSO for corrective or remedial training in the NCLT prior to the next FCLP period. This integrated approach more fully utilizes the trainer capabilities to promote acquisition of carrier landing skills by allowing the pilot to practice, in the trainer, those landing techniques that were identified as problem areas in the previous FCLP period. This individualized remedial training has been found to reduce recycle training in student pilots as well as to improve CQ performance.[4]

[4]See footnote 1, page 5

FIELD CARRIER LANDING PRACTICE (FCLP)

Pilot: PECYCLE IM

Squadron: VA122 (A7E)

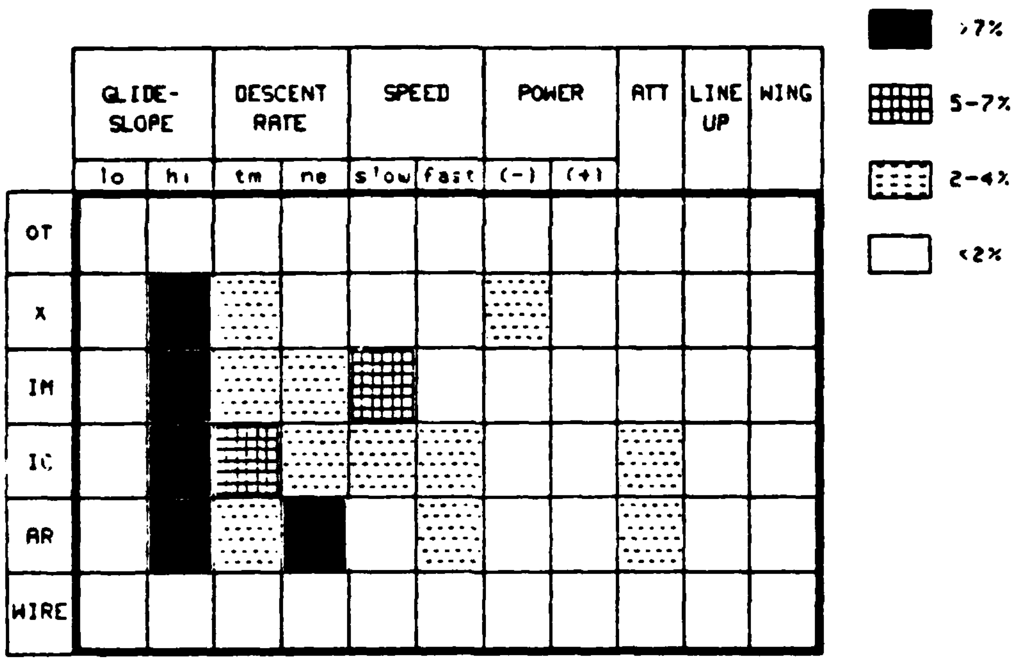
Date: 20FEB80 - NIGHT

Passes = 10

Period: 5

LANDING PROBLEM PROFILE

(Weighted LSO Comments)



Here are the three main problems which require corrections:

1. HIGH GLIDESLOPE AT THE RAMP 11.0 %
2. NOT ENOUGH RATE OF DESCENT AT THE RAMP 11.0 %
3. HIGH GLIDESLOPE IN THE MIDDLE 10.0 %

Figure 8. APARTS pilot performance graph output: Landing Problem Profile

FCLP PERFORMANCE SUMMARY. Another way to analyze FCLP performance is to plot a pilot's LSO grades over time. The FCLP Performance Summary presented in Figure 9 displays average LSO grades plotted for all day and night FCLP periods. The graph also provides the total number of passes, and inclusive dates, for both day and night FCLP performance. The FCLP Performance Summary is a useful and important data summary which portrays a pilot's learning acquisition curve over the course of FCLP training. LSO's can thus obtain an overview of pilot performance and determine the landing skill acquisition curve across FCLP periods. Accumulation of this type of information may ultimately be useful for identifying various learning rates associated with certain landing technique problems for replacement pilots. With such information available, LSO's could more readily stipulate, and assess, various levels of landing proficiency attainment across FCLP training periods. Once accumulated, the data base could provide the basis for syllabus validation and update as well as for the development of normative landing skill acquisition curves. Such data would be useful, not only for RP landing performance assessment and evaluation, but also for LSO training by allowing LSO's to become familiar with various types of landing problems associated with different aircraft/student pilot combinations.

In the example provided, the pilot FCLP performance peaked at the seventh night period and began to show a performance decrement thereafter. At period eleven, the pilot went to the boat for CQ trials. He failed to qualify. The example illustrates how APARTS can assist the LSO in "remembering" and summarizing longitudinal information that can be used to identify RP performance variations. Automation of FCLP performance data makes it easier for the LSO to track each RP and integrate his successive learning progress across FCLP periods. Early identification of RP performance trends allows the LSO to take timely and appropriate corrective action and reduces the likelihood for expensive recycle training.

FIELD CARRIER LANDING PRACTICE (FCLP)

Pilot: RECYCLE IM   Squadron: VA122 (A7E)

Dates: 11FEB80-16MAR80

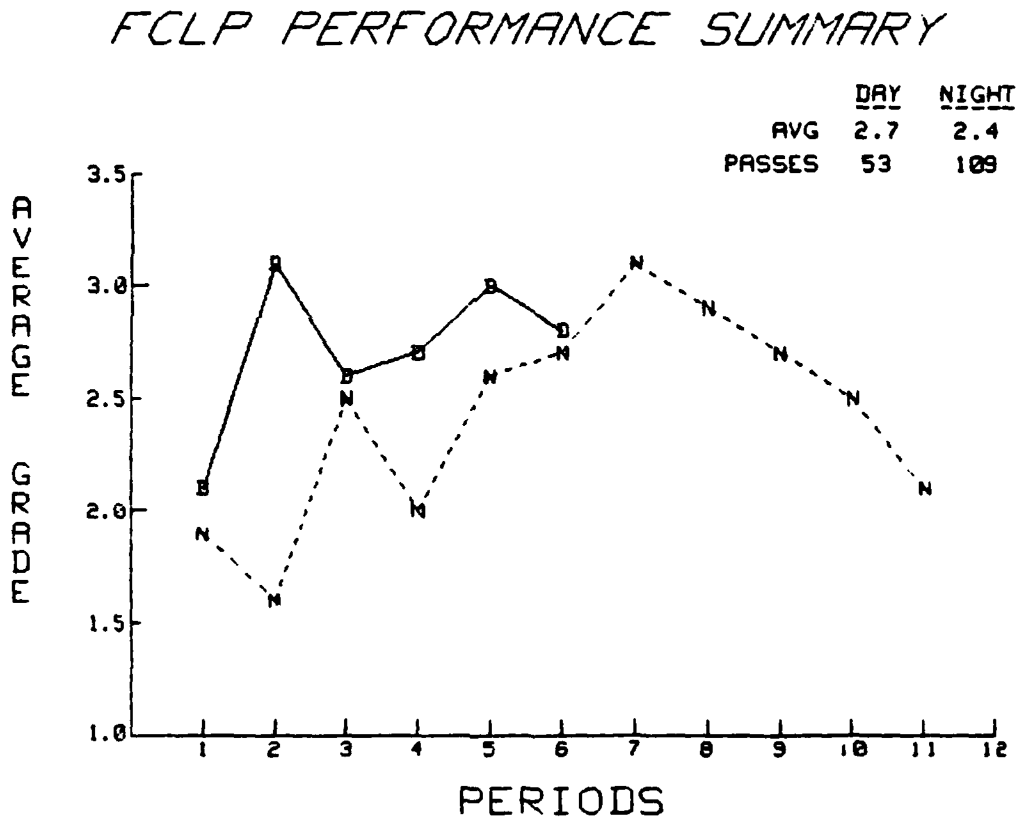


FIGURE 9. APARTS pilot performance graph output: FCLP Performance Summary

GENERIC PROBLEM ANALYSIS

An additional objective of this research was to develop preliminary methods or techniques to identify generic landing problems which may be common to novice A7 pilots. Development of these methods would be useful in structuring future pilot CQ training syllabi to reflect the common landing problems, and to provide appropriate instruction to facilitate their reduction. The techniques would also be of use in training LSO's to be aware of pilot landing problems with the A7 aircraft. Once the technique is established for determining A7-related landing problems, it could be used for other navy aircraft such as the A6, EA6, S3, F4, F14, and F/A18.

DATA SOURCES. The process of developing new methods began with the identification of several data sources. The following data sources were used:

1. FCLP performance data collected on 35 Category I A7 RP's from 1978 classes conducted at NAS Cecil Field, Florida.
2. FCLP performance data collected on 19 Category I A7 RP's during four 1980 training classes at NAS Lemoore, California.
3. Questionnaires administered to 19 Category I A7 RP's at NAS Lemoore. (See Appendix B.)
4. LSO critiques of pilot FCLP exercises conducted at NAS Cecil Field and NAS Lemoore. (N >3000 FCLP passes)
5. LSO interviews and analysis of FCLP data.

Initial sources consisted of LSO and pilot questionnaires, followed by personal interviews. These data were of particular importance and use in specifying the scope of landing problems and forming a general consensus of common landing problems.

Another important data source consisted of FCLP performance data collected on a number of A7 pilots who underwent CQ training with VA-174 (east coast) and VA-122 (west coast) FRS squadrons. It was believed that actual FCLP performance data could be analyzed in a manner which would isolate salient landing technique problems. Prior to the development of APARTS this type of landing problem analysis was virtually impossible due

to the extreme amount of time involved in manually processing the large amount of data. APARTS, however, provided the capability for immediate access to large quantities of FCLP data and was instrumental in processing the FCLP night landing data.

APARTS ANALYSIS OF GENERIC PROBLEMS. The preliminary method developed to identify generic landing technique problems was based upon the use of the standard APARTS software described above, augmented by some additional program capability. The method developed was as follows:

1. The standard APARTS software provided the capability for viewing a pilot's FCLP performance during a single FCLP period. A permanent program modification was made to the existing APARTS software (program PERREV) which enables data for one pilot to be combined across several FCLP periods. For example, data for a pilot's first five night FCLP periods, or any other combination of periods, can be combined, summarized and displayed as APARTS performance graphs. Documentation for this additional capability is included as part of the complete documentation for the APARTS programs.[5]
2. Next, program PERREV is loaded into the computer memory from cassette tape.
3. Once loaded into memory, program lines are temporarily inserted into the software. These statements form a program loop which provides the capability for combining data on as many pilots as present on the data base. Due to the exploratory nature of the analysis, and the inherent design of APARTS, this step is only a temporary solution for accumulating data across many pilots. APARTS software eventually will be permanently modified to incorporate the new capability.

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[5]See footnote 3, page 10

4. After inserting the new program lines the program is executed. Data for several pilots and dates are selected and read from tape. The data are then summarized as APARTS performanc graph outputs.

GENERIC FCLP PERFORMANCE GRAPHS. Data collected during several A7 CQ training classes were analyzed using the method described above. The results of this particular application of APARTS appear in a sequence of performance graphs which summarize night FCLP approaches by A7 RP's from both east and west coast FRS locations. While the results are only preliminary, they are reported here as an example of how common landing problems across pilots can be analyzed and graphically summarized by APARTS. Four graphs are presented in Figures 10, 11, 12 and 13. The reader will recall that these same graphs were used for individual pilot summaries. Here, they are used to summarize performance data for 19 pilots during the first five night FCLP periods covering 932 landing approaches.

In practice, the LSO could select any combination of FCLP periods he desired. He may want to look at only the first, or the fifth night period, or he may want to analyze only the last three night FCLP's before actual CQ trials. The system allows the LSO maximum flexibility in the selection of data to analyze. Once LSO's use the system, a standard analysis of data may be recommended. In the interim, the combination and summary of FCLP performance data across pilots provides an expanded data base for generic landing technique problem identification. APARTS can derive performance norms and standards using this capability to process, analyze and rapidly summarize pilot FCLP data.

In the graphs presented, the first five night FCLP periods are summarized. Probably the most important graph is the Landing Problem Profile (Figure 13) which summarizes the type, frequency and location of errors. Analysis of the graph shows that pilots generally experience difficulty with high starts, too much descent rate and high glideslope in the middle and in close, and end up slightly high at the ramp with not enough rate of descent. In order to verify these APARTS analyses, pilot and LSO questionnaire data were used to confirm the results.

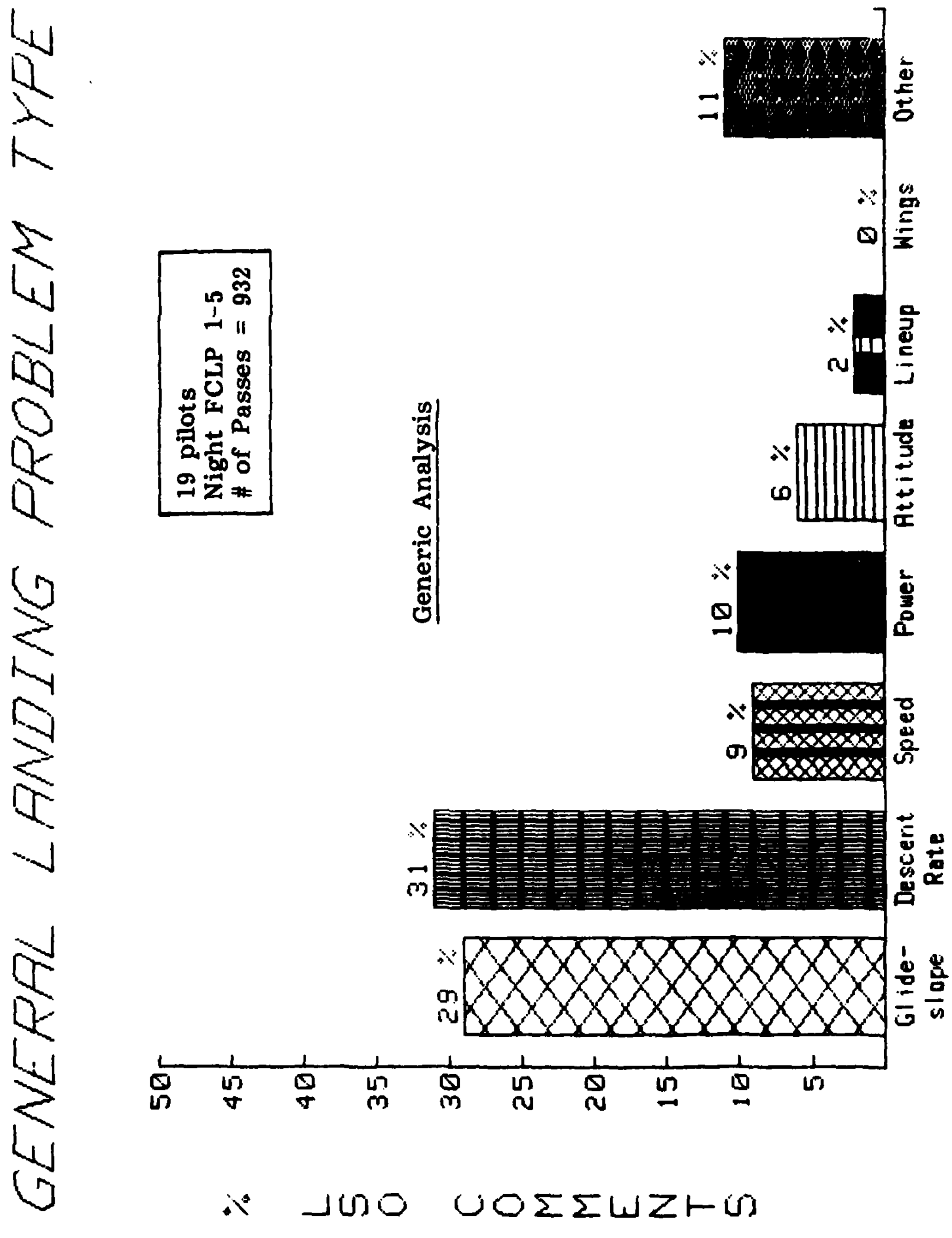


Figure 10. General Landing Problem Type: generic analysis

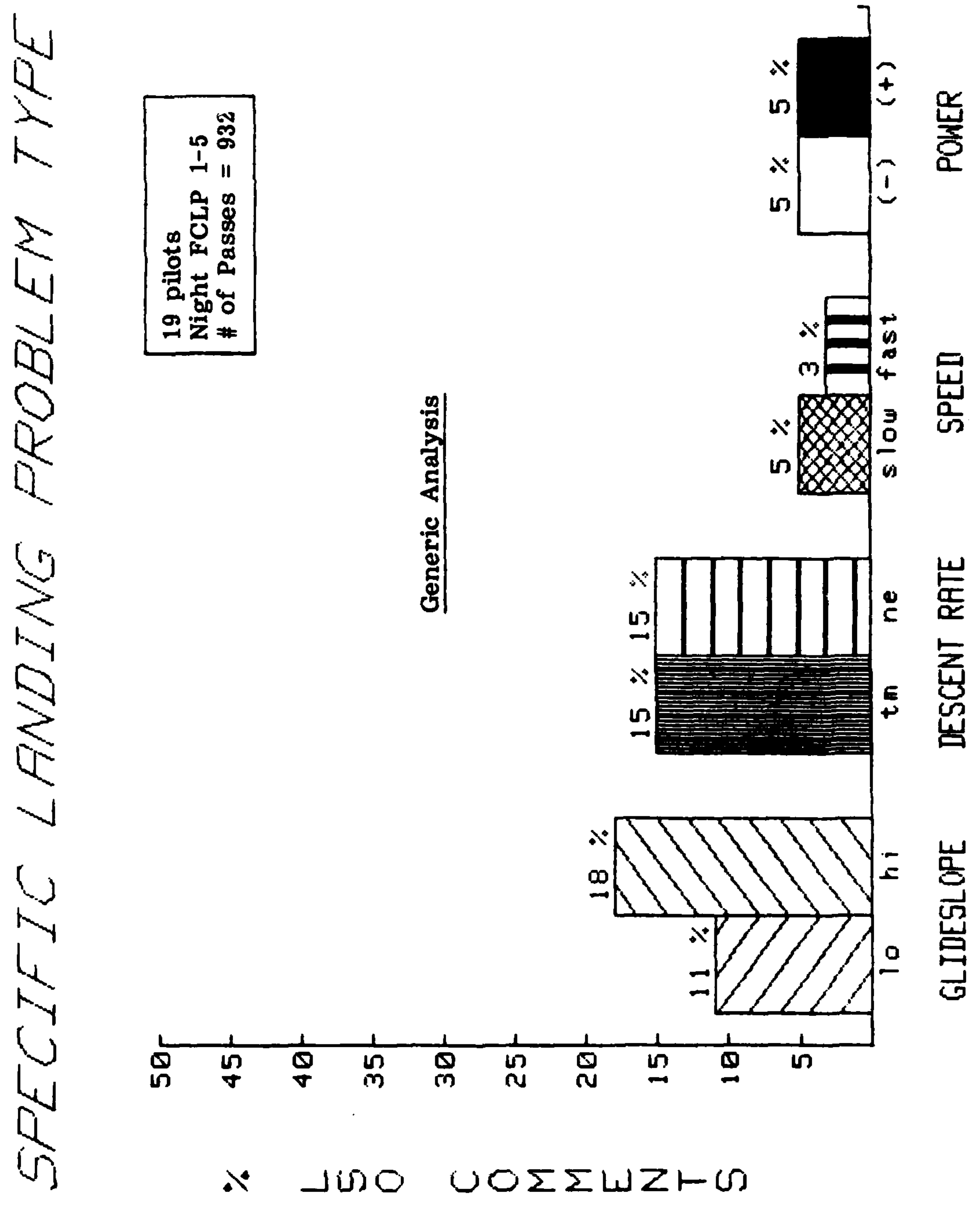


Figure 11. Specific Landing Problem Type: generic analysis

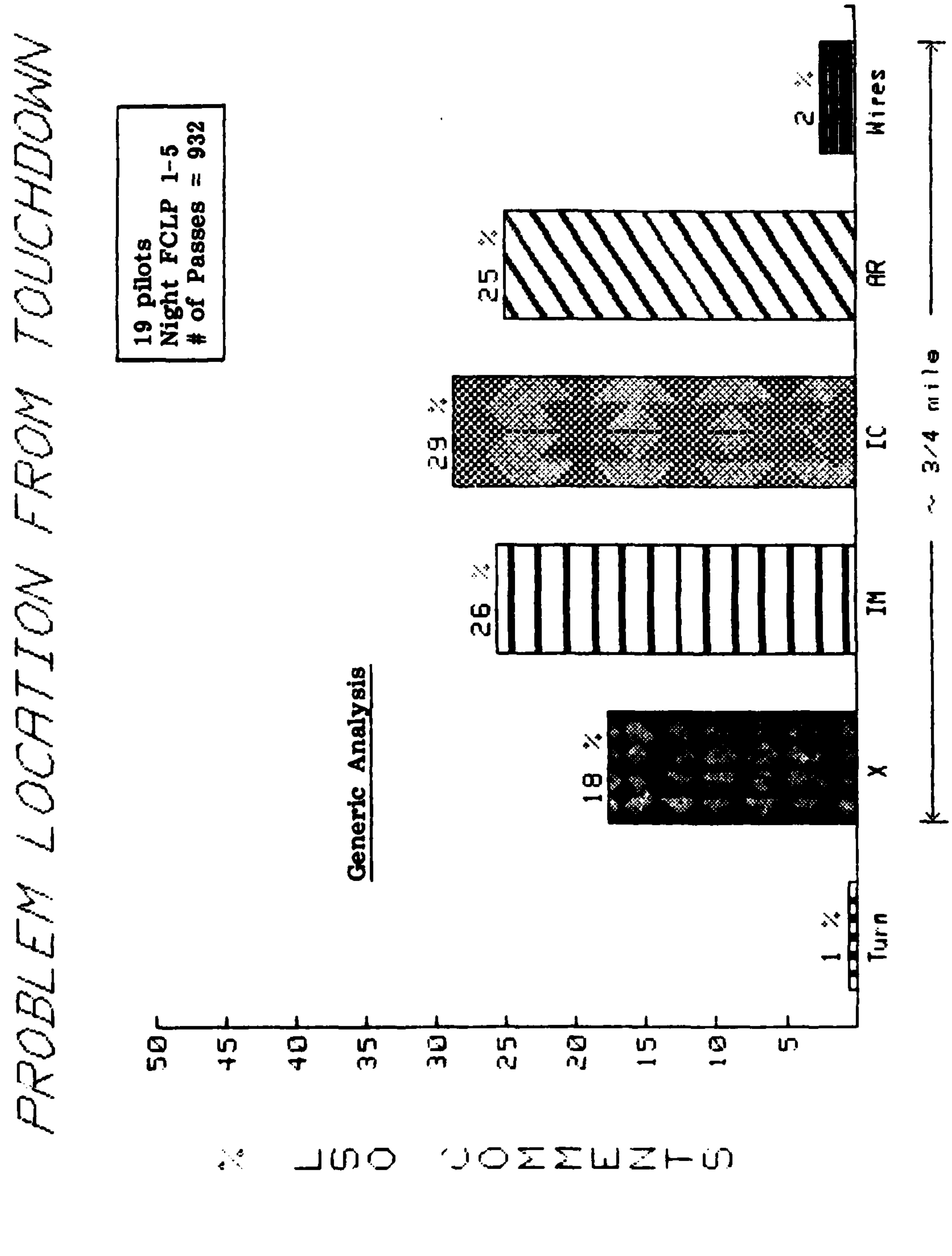


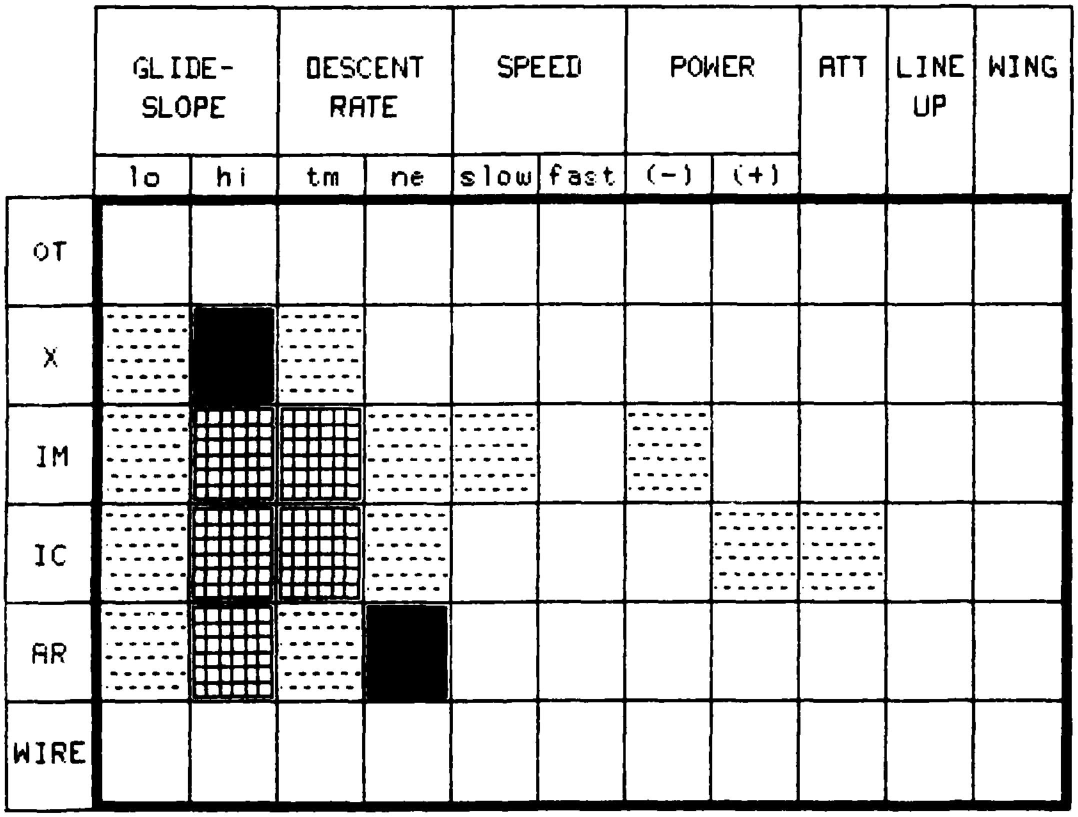
Figure 12. Problem Location From Touchdown: generic analysis

19 pilots
Night FCLP 1-5
# of Passes = 932

LANDING PROBLEM PROFILE

(Weighted LSO Comments)

GENERIC ANALYSIS



Here are the three main problems which require corrections:

1. NOT ENOUGH RATE OF DESCENT AT THE RAMP 7.2 %
2. HIGH GLIDESLOPE AT THE START 7.1 %
3. TOO MUCH RATE OF DESCENT IN THE MIDDLE 5.9 %

Figure 13. Landing Problem Profile: generic analysis

PILOT AND LSO QUESTIONNAIRES. While actual FCLP performance data were analyzed according to the methods described above, the pilot questionnaire and LSO critique data were used to provide additional information on the problems unique to A7 RP's. An analysis of these data was performed in order to confirm and amplify the results of the computer analyses.

A7 RP's were surveyed during their CQ phase training and each pilot filled out a questionnaire covering his general impressions. Table 1 summarizes some of the pilot responses. In general, the responses reflect the APARTS generic problem identification. Although the pilot responses are in their vernacular, and based on what they perceived as problems from the cockpit (as compared to what the LSO sees from the field), they tend to support the generic landing problem profile. The comments typically mention high starts, settle in middle, and difficulty in controlling for glideslope (power response lag). The precise skills for throttle and stick control required to stay on glideslope, fly the ball and maintain a constant rate of descent are the primary problems from a pilot's point of view. These problems are reflected in the generic problem profile which emphasizes erratic glidescope and descent rate patterns throughout the approach, especially at the start and at the ramp.

Additional verification of the resulting list of problem areas was obtained through LSO interviews, feedback and evaluation. Specifically, LSO's were utilized as subject matter experts (SME's) to confirm both the methods used and the results obtained from the generic problem analysis research. Table 2 summarizes FRS LSO answers to common problems Category I pilots typically encounter in first learning how to land the A7E aircraft during night FCLP.

Again, lack of precise glideslope control, as typified by high starts, settle in the middle, and high at the ramp tend to reflect the types of generic problems encountered.

TABLE 1. SUMMARY OF TYPICAL RESPONSES TO A7 PILOT SURVEY QUESTION

What was the most difficult landing technique problem you encountered during FCLP?

"High starts."

"Settle in the middle."

"Flying the ball. Settle in the middle seemed by far the most common difficulty and hardest to correct."

"Nose movement in close. Using power vice nose to control ball from the in close position."

"Out of the turn I would increase my angle of bank to stop from overshooting and thus my rate of descent would increase while I was pulling back power."

"Concentration on the ball. Fighting the urge to look at lineup too much."

"Running out of juice at the ramp or working a low ball at the ramp."

"Staying ahead of aircraft tendency to settle and climb. Keeping the ball in parameters at the start."

"Overcontrolling the nose, using the nose for glideslope, instead of power."

"Seeing and anticipating ball movement."

"Anticipating ball movement."

"Precise coordination of airspeed with glideslope corrections."

"Rough corrections off a bad start."

"Using the nose along with power to maintain the ball."

"Anticipating the power lag of the A7E."

TABLE 2. LIST OF LSO SUMMARY OF TYPICAL PASSES THEY MOST COMMONLY SEE A7E CATEGORY I PILOTS FLY

SX LOBAW NEPBIM LOAR

Typical night, RP doesn't scan VSI or fuel flow and settles on ball call (at the start). He sees the ball go low, adds power and flattens out. As he sees the ball move up again to the middle or a little high, he brings power back and goes low in close or at ramp.

SRDIC HNDCDAR

Pilot stops rate of descent in the middle with too much power, sees ball climb in close and goes for it.

NEPX LOIM

RP gets underpowered and just looks at the ball and doesn't see low ball developing and gets waved off.

SX OCLOIM HIC AR

RP goes from IFR to VFR world and feels high. Pulls power and settles. Finally sees low in the middle, over-controls it and flies through the glideslope in close and at the ramp.

SIM LOBIC-AR

Pilot reduces power out of turn and fails to recorrect in the middle. Tries to finesse low ball in close and winds up flat at the ramp and bolters.

SECTION V

APARTS DEVELOPMENT AND PRELIMINARY USER ACCEPTANCE TESTS

APARTS development reviews and preliminary user acceptance tests were the two approaches followed in obtaining LSO user acceptance. These approaches were taken to ensure that APARTS would be developed in concert with LSO requirements and that the system would be both accepted and utilized by the personnel for whom it was designed. During the early stages of the development cycle, user inputs were obtained via review sessions with LSO's from the fleet, FRS, Carrier Air Group (CAG), and staffs. Most of the iterative review sessions were held with LSO's from VA-122 (A7), VA-128 (A6), and VFR-302 (F4) to review and critique the computer outputs. Their reviews were invaluable in ensuring that APARTS capabilities were used to meet LSO training requirements for RP's and that the performance review graphs were meaningful, understandable and acceptable.

After completing development of the computer programs for APARTS, the system was tested in the field and many demonstrations were provided to navy personnel to obtain user feedback and suggestions for any revisions or improvements. A preliminary field test was conducted at NAS Lemoore, California during actual CQ training conducted by VA-122. FCLP data obtained during this training period were used as inputs to APARTS. In the test, the system readily accepted and processed as input the LSO comments; all data entry went smoothly which resulted in meaningful outputs for the LSO's and pilots; and, program outputs were provided in a timely manner and used by LSO's to identify and correct landing technique problems. The program outputs were also used for administrative convenience by providing data for CQ completion letters for each pilot. Although the field test was preliminary and by no means an exhaustive one, the LSO consensus and results indicate the use of APARTS was successful. These favorable results also reflected the potential utilization of APARTS as an integrated training aid for LSO's.

A final review test for APARTS was provided at a demonstration given at the West Coast LSO Naval Air Training and Operating Procedures Standarization (NATOPS) Conference held at NAS Miramar, California in October 1980. LSO's representing every west coast Navy community were present at this conference. As a result of the hands-on-demonstration, the LSO's unanimously endorsed the system and indicated that APARTS would be a useful addition to RP carrier landing training in each of their communities. As a result, a COMNAVAIRPAC letter of support was forwarded to the Chief of Naval Operations (OP-059) as an indication of operational need and support for further procurement and greater field testing to tailor the system to each aircraft community.

ALTERNATE APARTS SYSTEMS

During the acceptance testing phase of the APARTS development cycle a number of alternative computer hardware systems were briefly explored to determine if a lower cost, more widespread medium could eventually be utilized for APARTS. One such alternative is the Aviation Training Support System (ATSS) which will soon be available at many Naval Air Stations throughout the United States. ATSS is essentially an administrative and scheduling system to support a large number of record keeping requirements for enlisted and officer personnel. The primary advantage of ATSS to the current APARTS medium is the general use and large data storage capability available at all Naval Air Stations.

Prior to selecting a hardware system to serve as a vehicle for implementing APARTS, a thorough study of ATSS and other candidate systems should be conducted. This research should focus on determining the extent to which alternative system capabilities can meet current and anticipated APARTS requirements. These requirements include, in part, the following:

1. Guaranteed easy and frequent LSO accessibility,
2. CRT graphics capability,
3. Mass data storage,

4. Low costs to convert software,
5. Reliable system maintenance to ensure availability, and
6. User friendly for ease of operation.

These general criteria will be applied to ATSS and other candidate systems that may be potential candidates for APARTS incorporation. In the interim, the APARTS will utilize the equipment configuration as described in this report.

SECTION VI

APARTS RECOMMENDATIONS

Four general areas in which future APARTS research should be directed are:

1. FRS field tests,
2. Software development,
3. Media analysis, and
4. Applications.

FRS FIELD TESTS

The initial field test conducted with APARTS was preliminary and of limited duration. Additional field tests should be conducted over a six-month period at a minimum of two FRS locations. This evaluation period is required to ensure that the system works properly in the field, and to solicit comments from the users about the system's operation. In addition to those factors, APARTS should also be evaluated on the basis of training impact, safety and costs involved with implementing the system. Prior to these tests, a detailed procedures and operator instruction manual should be developed and operators should be trained in the use of APARTS. Once manuals are developed, APARTS utilization should be closely monitored and evaluated through the field tests.

SOFTWARE DEVELOPMENT

Updates should be made to the APARTS software programs. These software changes should include some of the suggestions made during the initial field test (i.e., accomodate some of the different LSO comments made at each FRS location) as well as recommendations made from the six-month field tests. Further, all of the performance graphs should be updated to include normative data so that a pilot's performance can be compared against a standard. An additional module should be added to APARTS which would provide the capability for analyzing CQ data as well as output the pilot's completion letters.

Other software updates should be made and reflected in a modified APARTS program based on a consensus of user recommendations.

MEDIA ANALYSIS

Alternate hardware media, for implementation of APARTS concepts, such as ATSS and other computer hardware, should be thoroughly examined. This analysis should determine the extent to which alternative systems can meet APARTS specifications outlined in the report. From this analysis final hardware specifications should be written for implementation of APARTS at each location.

APPLICATIONS

The APARTS application described above in which generic landing technique problems are identified should be further developed. Not only should generic landing technique problems be specified for pilots flying A7 aircraft, but other navy aircraft as well. Norms could then be established across different aircraft types which could be used for LSO training at Phase I School. This process would require the collection of large amounts of FCLP data from different FRS communities. Once collected, the data would be entered into APARTS and generic problems could be identified for each aircraft type. Finally, research should be conducted to explore alternative APARTS training techniques for aircraft communities which do not have an NCLT. For example, available F14 simulators should be explored for carrier landing training and remediation capability. Integrated training methods should then be developed using alternative training media and techniques to allow APARTS concepts to be implemented with aircraft communities which do not have an NCLT.

APPENDIX A

PRELIMINARY OPERATOR INSTRUCTIONS FOR APARTS SOFTWARE PROGRAMS

The following is a simple description of steps and procedures required to operate both the Editor and PERREV programs. Descriptions will be limited primarily to the basic functions performed by the programs and will not cover many of the program branches.

START-UP

To begin operation of the system the following steps must be performed.

1. Insert the cassette tape containing the APARTS program files into the right-hand tape drive labeled "T15."
2. Insert the APARTS data files tape into the left tape drive marked "T14."
3. Depress until latched the Edit/System Function key labeled "AUTO ST."
4. On the right-hand side of the machine, turn the power switch to the "1" position.

Immediately the system will begin reading from the right-hand tape a program which draws messages on the CRT. These messages were designed to greet the operator and explain the purpose of APARTS. Once all messages have been drawn the computer automatically begins transferring the Editor program instructions from the program tape into memory.

When the transfer is complete, Editor automatically begins executing. Next, some data are read from the data tape, and the Editor function menu is displayed on the CRT. An illustration of the menu as displayed to the user on the CRT is presented in Figure A-1.

Which of these functions do you wish to perform?
1 - ADD NEW DATA
2 - LIST FCLP GRADE FORM DATA
3 - CHANGE PREVIOUSLY STORED DATA
4 - VIEW GRAPHS OF A PILOT'S PERFORMANCE
5 - STOP THE PROGRAM

ENTER A NUMBER and then PRESS CONT

Figure A-1. Editor Function Menu

Once the Editor function menu is displayed on the CRT the user can perform any of the functions by simply entering the corresponding numeric value on the keyboard. For example, if a value of "1" is entered, a sub-program is executed which allows the user to add new data from the FCLP Grade Sheet.

Entering data into the system via the add function is easy since the user is always prompted prior to input. Prompts are sequenced so that data is transcribed exactly as it appears on the FCLP Grade Sheet. Demographic data such as names and dates are verified by the system upon entry to ensure accuracy. Pilot names are also checked against other names stored on the data base so that the data for the same person will not be stored under different names. Performance data are checked by the system for syntax and format in order to standardize and ensure quality control of LSO grades and comments. The user is immediately notified when any data are rejected by the system.

After all data have been correctly entered the Editor function menu is displayed again on the CRT. Should the user next desire to list selected FCLP data a value of "2" must be entered on the keyboard. Upon entry of the proper value, the list function begins execution by displaying a list of pilot names along with numbers on the CRT. To access data for a particular pilot the user needs only to enter the number corresponding to the pilot name.

Likewise, a list of dates is printed on the CRT so that the user needs to enter just a single number corresponding to a specific date. Immediately, the selected data are read from tape and FCLP Grade Sheet data are displayed on the CRT. Optionally, the user can obtain a printed copy of these data and also the corresponding FCLP Trend Analysis.

Upon being prompted with the Editor function menu, the user can execute the change function by entering a value of "3" on the keyboard. This function enables the user to correct any mistakes identified on the FCLP data base. Prior to making actual changes with the data the user must first make selections. Pilot names and dates are selected using the identifical steps set forth with the list function above. Once selected, the system reads the data from tape and displays the FCLP data on the CRT. Next to each line of data displayed on the CRT is a number. To change data, the user simply enters the number of the line to be changed on the keyboard and then makes changes to the actual data. Once corrected, all data are restored on tape, an updated FCLP Trend Analysis is output and the Editor function menu is displayed on the CRT.

Entering a value of "4" causes the system to read and begin execution of the PERREV program. Prior to viewing any graphic presentations with program PERREV the user is interactively prompted for information. First, the user is asked to specify options such as obtaining hard copy printouts of graphs and automated presentation of all graphs. After choosing options, the user selects, as described above, the pilot name and date for which data are to be viewed. Once selected, the PERREV software causes the system to read from tape all the appropriate data.

After reading the proper data from tape, program PERREV displays on the CRT a menu of graphs which the user may select for viewing. An illustration of the PERREV graph menu is presented in Figure A-2. To choose any particular graph, the user is required to enter the number corresponding to the graph of interest on the computer keyboard. The computer will then draw the desired graphic presentation on the CRT. If the hard copy option had been selected, the contents of the CRT would be printed along with some

demographic data on the thermal printer. Also, if the automated presentation option had been chosen, the computer would begin drawing the first graph and proceed to automatically draw all the other graphs in consecutive order.

```
Which of these graphs do you wish to view?
    1 - GENERAL LANDING PROBLEMS
    2 - SPECIFIC LANDING PROBLEMS
    3 - LANDING PROBLEM LOCATIONS
    4 - LANDING PROBLEM PROFILE
    5 - FCLP PERFORMANCE SUMMARY
```

ENTER A NUMBER and then PRESS CONT

Figure A-2. PERREV Graph Menu

After all the desired performance graphs have been viewed for a particular pilot and date, the user has the capability for viewing graphs based upon data for different dates and pilots. If no additional graphs are to be viewed the user has the option of either editing data, which loads the Editor program again, or terminating the program.

APPENDIX B

A7 FCLP SURVEY

RP Name____Date____________

1. What was the single most difficult landing technique problem you encountered during FCLP? ____

2. When did this problem first occur during FCLP training? (i.e., at the very beginning of FCLP training, towards the middle, at the end, etc.)
____

3. What specifically helped you to overcome this landing technique problem?
____
____
____

4. What, if any, were some of the other landing technique problems you encountered? ____

5. How, specifically, were these problems remedied? __________________
____
____
____

6. In your opinion, what are the unique problems involved in learning how to land the A7E as compared to other aircraft? __________________
____
____
____

7. During Phase III training did you have any TA7 rides with a flight instructor? Yes_____ No_____
If yes, what benefits did these rides provide you? __________________
____
____
____

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Code S-3311
New Orleans, LA 70146

Headquarters 34 Tactical Airlift
Training Group/TTDI
Little Rock AFB, AK 72076

Federal Aviation Administration
AAC-954C
Aeronautical Center, Flight Standards
Branch
Oklahoma City, OK 73101

Chief, Methodology and Standards
Staff
Federal Aviation Administration
Academy
Aeronautical Center, AAC - 914
P.O. Box 25082
Oklahoma City, OK 73125

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Counterfire Department
Attn: Eugene C. Rogers
Ft. Sill, OK 73503

Commandant
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ATSF-TD-TS (Mr. Inman)
Ft. Sill, OK 73503

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Randolph AFB, TX 78148

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San Antonio, TX 78200

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Branch
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TSZ
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AFHRL/PE
Brooks AFB, TX 78235

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Attn: Code 3146 (LSO)
NAS Corpus Christi, TX 78419

Chief of Naval Air Training
ATTN: Code 333
NAS Corpus Christi, TX 78419

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Flying Training Division
Williams AFB, AZ 85224

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Liaison Office
Human Resources Laboratory
Flying Training Division
Williams AFB, AZ 85224

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AFHRL-OT
Operational Training Division
Williams AFB, AZ 85224

AFHRL/OTO
Luke AFB, AZ 85309

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Center, Pacific
Code N5B (Mr. Rothenberg)
San Diego, CA 92132

Commander, Naval Air Force
U.S. Pacific Fleet (Code 311 L)
NAS North Island
San Diego, CA 92135

Commander, Naval Air Force
U.S. Pacific Fleet (Code 342)
NAS North Island
San Diego, CA 92135

Commander, Naval Air Force
U.S. Pacific Fleet (Code 316)
NAS North Island
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Naval Station
San Diego, CA 92136

Commander, Training Command
Attn: Educational Advisor
U.S. Pacific Fleet
San Diego, CA 92147

Commanding Officer
Fleet Combat Training Center, Pacific
Code 09A
San Diego, CA 92147

Commanding Officer
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Pacific Missile Test Center
Point Mugu, CA 93042

LT Wayne R. Helm
Human Factors, Engineering
Code 1226
Point Mugu, CA 93042

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Code 3154 (Mr. Bob Curtis)
China Lake, CA 93555

Plans Officer Psychologist
Ft. Ord, CA 93941

National Aeronautical and Space
Administration
Ames Research Center Aircraft
Inspection Branch
Mail Stop 211-5
Moffett Field, CA 95050